Using Fluctuation Microscopy to Detect the Medium Range Order in Disordered Materials

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In this poster we present some results from our X-ray and optical fluctuation microscopy studies of disordered materials. Fluctuation microscopy is sensitive to any medium range order present in amorphous and disordered materials, and obtains this sensitivity by examining the spatial fluctuations in coherent diffraction scattering. The method derives this sensitivity because the normalized variance depends on pair-pair correlation functions and hence can be used to detect the subtle structural correlations.

We are exploring two variations of the fluctuation microscopy idea. One promising approach, for varying the resolution function within the same scan, is to use an elliptical (or rectangular) probe-forming aperture. The idea is that diffraction data along the narrow slit direction corresponds to low-resolution (*i.e.* large sample volumes), whereas diffraction data along the wide slit direction corresponds to high-resolution data (*i.e.* small sample volumes). The (admittedly simplistic) idea is that all sampling resolutions between these two extrema can be found by tracing the diffraction data along the azimuthal angle corresponding to the desired aperture width. This approach may eliminate the need for taking a series of scans at different probe. We are testing this idea on our fluctuation optical microscopy (FOM) set-up using a rectangular slit. The idea works well for the diffraction data. However, interpreting the normalized variance data is complicated by the pair-pair dependency.

The second approach is to obtain the pair-pair correlations directly by scanning two coherent probes across the sample. Regions that are scattering coherently onto the diffraction plane will generate Young's fringes. In principle, when the probes are separated further than the structural correlation width, the Young's fringes will disappear when averaged over the sample. This mode of fluctuation microscopy is related to holography. However, here, the reference beam is another sample volume rather than an undisturbed beam. This second method has been tested on our FOM set-up using double pinhole arrangements, and has been tested at the 2-ID-B beamline at the APS using two overlapping zone plates. We will discuss our data and a number of interesting challenges that remain.